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(54) Combustion system with low pollutant emission for gas turbines

Verbrennungsanlage mit niedriger Schadstoffemission für Gasturbinen

Système de combustion à pollution réduite pour turbines à gaz

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- **PATENT ABSTRACTS OF JAPAN vol. 7, no. 165 (M-230)(1310) 20 July 1983 & JP-A-58 072 822 (HITACHI SEISAKUSHO) 30 April 1983**

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Description

This invention relates to a combustion system for gas turbines which provides efficient and precise combustion air control on the basis of the turbine loading, ensures permanent flame stability, prevents the cooling air interfering in any way with the combustion and imposes a more or less accentuated rotary movement on the air-fuel mixture, hence minimizing pollutant nitrogen oxide and carbon monoxide emission at all turbine loading levels, such type of combustion system is disclosed in the document EP-A-488766. The formation of pollutant nitrogen oxides is known to increase with increasing combustion or flame temperature.

In the usual known combustion systems of the so-called diffusion type in which the fuel is injected into a combustion chamber surrounded by an interspace containing pressurized air flowing counter-currently to the stream of combustion products and comprising holes for the combustion air, small intermediate apertures distributed over the entire chamber surface for the chamber cooling air and holes for the dilution air which reduces the temperature of the combustion products to a level acceptable by the turbine, the fuel burns an air quantity always equal to the stoichiometric value and hence always with a high energy concentration and a high temperature whatever the excess air present, and hence without consequent flame stability problems even under low load, but with evident high pollutant emission. In order to reduce this pollutant emission, use is generally made of combustion systems with pre-mixing in which upstream of the combustion chamber, from which it is separated by a constriction and which is also surrounded by said interspace containing pressurized air, there is provided a pre-mixing chamber into which both the fuel and said combustion air are fed, these mixing at low temperature to substantially dilute the fuel before reaching the combustion chamber, so that said combustion is no longer stoichiometric but instead takes place with an excess of air and hence at a lower temperature.

It has now been found that to achieve low pollutant emission of nitrogen oxides and carbon monoxide together with good flame stability it is necessary to maintain the combustion air/fuel ratio around an optimum value corresponding to an air excess of between 1.5 and 2 times the stoichiometric value, this being achievable with pre-mixing combustion systems at all turbine loading levels.

In this respect, whereas the air flow fed to said combustion systems generally by an axial compressor remains substantially constant, the fuel quantity has to be varied continuously on the basis of the turbine loading, so that if said optimum air excess is achieved at full load, it is no longer achieved when the turbine is used at reduced load, ie when using a smaller fuel quantity. In such cases the air excess can reach between 4 and 7 times the stoichiometric value, with the consequent danger of the flame extinguishing.

In addition to the said possible extinguishing of the flame, a further drawback of pre-mixing combustion systems is that they easily produce unstable combustion due to the fact that the low energy concentration present makes the flame sensitive to the smallest disturbances, hence producing deleterious pressure pulsation within the combustion chamber.

The object of the present invention is to obviate the aforesaid drawbacks by providing a combustion system of pre-mixing type which maintains the combustion air/fuel ratio substantially constant at its optimum value at all turbine loading levels and always ensures flame presence and stability, with consequent minimizing of pollutant emission.

This is substantially attained in that the combustion air path from the interspace into the pre-mixing chamber via apertures provided in the outer surface of this latter is interrupted by a valving member consisting in practice of a drum rotatable on said outer surface of the pre-mixing chamber and provided with corresponding apertures arranged to cooperate with said apertures in the pre-mixing chamber, said drum being driven by an actuator, the pinion of which engages a gear sector rigid with the drum so as to vary the degree of opening of said corresponding apertures on the basis of the fuel quantity used.

In this manner, depending on the angular position of the valving drum and hence of its apertures relative to the apertures of the pre-mixing chamber, these latter can be either completely open or their degree of opening reduced until total closure is achieved.

Hence when the turbine is to operate at reduced load and thus with less fuel, it is necessary merely to conveniently reduce the degree of opening of said apertures to appropriately reduce the air to its optimum value to achieve low pollutant emission, because in this manner a restriction is created at the apertures so that instead of passing through this restriction the air prefers to enter the combustion chamber through the dilution air holes.

The surface of the constriction which joins the pre-mixing chamber to the combustion chamber, and downstream of which the flame develops, is provided with a series of small holes for additional injection of fuel, which creates a fuel-rich front in the flame region and hence makes the flame stable.

Hence, the combustion system for gas turbines, comprising a combustion chamber provided with small apertures distributed over the entire chamber surface for the chamber cooling air and with holes for the dilution air which reduces the temperature of the combustion products leaving the chamber, this being surrounded by an interspace containing pressurized air flowing counter-currently to the stream of said combustion products, which interspace also surrounds a pre-mixing chamber in which the fuel is mixed with the combustion air and which is positioned upstream of said combustion chamber and separated therefrom by a constriction, is char-

acterised according to the present invention in that said combustion air is taken from said interspace via a series of apertures provided in the outer surface of said pre-mixing chamber and cooperating with corresponding apertures in a drum rotatable on said outer surface of the pre-mixing chamber, said drum being driven, to vary the degree of opening of said corresponding apertures in accordance with the fuel quantity used, by an actuator the pinion of which engages a gear sector rigid with the drum, and in that the surface of said constriction is provided with a series of small holes fed with additional fuel.

Furthermore, in order to facilitate more effective and homogeneous mixing, according to a preferred embodiment of the present invention said pre-mixing chamber has an annular cross-section smoothly blending into said separating constriction and comprises in its annular interior a radial series of perforated tubes fed with the fuel to be mixed.

The combustion system of the present invention also comprises further flame stabilization expedients, to be used, under certain conditions, instead of or together with the additional fuel injection through the small holes in the constriction.

One of these expedients consists of a central burner positioned within said pre-mixing chamber and fed with additional fuel to effect further fuel injection into the the combustion zone downstream of said constriction.

The other expedient comprises a series of blades previously set at a predetermined adjustable angle to the air-fuel mixture stream within the annular interior of said pre-mixing chamber in proximity to said constriction.

In this manner, rotary motion is induced on the mixture within the annular chamber to a greater or lesser extent depending on the blade angle, this having a beneficial effect on flame stability.

Finally it is believed, as experimental tests would seem to confirm, that the presence of cooling air within the combustion zone immediately downstream of the constriction can disturb the combustion and in particular result in an increase in carbon monoxide, according to a further characteristic of the present invention the combustion chamber is cooled in a differential manner, in that that part of the combustion chamber surface in correspondence with the combustion zone downstream of the constriction is no longer provided with distributed small apertures for the cooling air, but instead is without apertures, and together with an outer wall provided with a large number of small holes close together defines a small cooling chamber which communicates with the combustion chamber via collector holes provided in that end of said small chamber further from said constriction.

In this manner, the air which enters said small chamber under pressure from the interspace by passing through said small holes in the outer wall creates a number of air blasts against the inner wall of the small chamber and hence against the surface of the combustion chamber, which effectively cool it to then flow into the combustion chamber but at such a distance away as not to be able to influence the combustion zone.

The invention is described in detail hereinafter with reference to the accompanying drawing, which shows a preferred non-limiting embodiment thereof, in that technical or constructional modifications can be made thereto but without leaving the scope of the present invention. For example, instead of using a pinion engaging a gear sector, said drum can be driven by any other drive system.

In said drawing the figure represents a multi-sectional side view of a gas turbine combustion system formed in accordance with the invention.

In the figure, the reference numeral 1 indicates the combustion chamber of a gas turbine combustion system, having its upstream end connected to a pre-mixing chamber 2 via a constriction 3, immediately downstream of which there is the actual combustion zone 4 of the chamber 1. The entire assembly is surrounded by an interspace 5 containing air fed under pressure by an axial compressor, not shown in the figure, and flowing in the direction of the arrows 6, ie counter-currently to the stream 7 of combustion products leaving the combustion chamber 1.

The outer surface 8 of the combustion chamber 1 is provided with small deflector apertures 9 for the chamber cooling air 10 and, in the downstream part of the chamber, with holes 11 for air 12 used to dilute the combustion products in order to reduce their temperature to a level acceptable to the turbine. That part 8' of the surface 8 of the combustion chamber 1 surrounding the combustion zone 4 is without apertures 9, and together with an outer wall 13 provided with a large number of small holes 14 positioned close together defines a small cooling chamber 15. In this respect, the pressurized air 16 passing through said small holes 14 generates a large number of air blasts against the surface 8', which is hence effectively cooled without the cooling air 16 being able to influence the combustion zone 4 in any way as said air is made to flow into the combustion chamber 1 through collector holes 17 (only one is visible in the figure) provided in that end of the small chamber 15 further from the constriction 3.

Said pre-mixing chamber 2 has an annular cross-section smoothly blending into the interspace 3 and comprises in its annular interior a radial series of perforated tubes 18 which are fed with the fuel to be mixed via the annular chamber 19 and the pipe 20 passing through the central cavity 21 in the pre-mixing chamber 2.

In said annular interior 2 in proximity to the interspace 3 there are also provided blades 22 which by means of the pin 23 and fixing nut 24 can be set at a predetermined angle to the air-fuel mixture stream to impress a more or less accentuated rotary movement on the mixture to favour flame stabilization.

The combustion air is conveyed from the interspace 5 into the premixing chamber 2 via a series of apertures

25 provided in the outer surface 26 of said chamber. Said apertures 25 cooperate with corresponding apertures 27 in a drum 28 which is rotatable on said outer surface 26 and is rotated in such a manner as to vary the degree of opening of said apertures 25 in accordance with the quantity of fuel used. The drum 28 is rotated by an actuator 29, the pinion 30 of which engages a gear sector 31 rigid with the drum 28.

The figure also shows a central burner 32 inserted into said central cavity 21 and fed with additional fuel via the pipe 33, to inject further fuel into the combustion zone 4 to maintain the flame stable.

Finally, to achieve effective flame stabilization the surface of the interspace 3 is provided with a series of small holes 34 fed with additional fuel via the annular chamber 35 and pipe 36.

Claims

1. A combustion system for gas turbines, comprising a combustion chamber provided with small apertures distributed over the entire chamber surface for the chamber cooling air, and with holes for the dilution air which reduces the temperature of the combustion products heaving the chamber, this being surrounded by an interspace containing pressurized air flowing counter-currently to the stream of said combustion products, which interspace also surrounds a pre-mixing chamber in which the fuel is mixed with the combustion air and which is positioned upstream of said combustion chamber and separated therefrom by a constriction, characterised in that said combustion air is taken from said interspace via a series of apertures provided in the outer surface of said pre-mixing chamber and cooperating with corresponding apertures in a drum rotatable on said outer surface of the pre-mixing chamber, said drum being driven, to vary the degree of opening of said corresponding apertures in accordance with the fuel quantity used, by an actuator the pinion of which engages a gear sector rigid with the drum, and in that the surface of said constriction is provided with a series of small holes fed with additional fuel.

2. A combustion system for gas turbines as claimed in claim 1, characterised in that said pre-mixing chamber has an annular cross-section smoothly blending into said separating constriction and comprises in its annular interior a radial series of perforated tubes fed with the fuel to be mixed.

3. A combustion system for gas turbines as claimed in claim 1, characterised in that a central burner positioned within said pre-mixing chamber and fed with additional fuel effects further fuel injection into the combustion zone downstream of said constriction.

4. A combustion system for gas turbines as claimed in claim 2, characterised in that a series of blades is provided previously set at a predetermined adjustable angle to the air-fuel mixture stream within the annular interior of said pre-mixing chamber in proximity to said constriction.

5. A combustion system for gas turbines as claimed in claim 1, characterised in that that part of the combustion chamber surface in correspondence with the combustion zone downstream of the constriction is without apertures, and together with an outer wall provided with a large number of small holes close together defines a small cooling chamber which communicates with the combustion chamber via collector holes provided in that end of said small chamber further from said constriction.

Revendications

1. Système de combustion pour des turbines à gaz, comprenant une chambre de combustion pourvue de petites ouvertures, réparties sur toute la surface de la chambre et destinées à l'air de refroidissement de la chambre, et de trous pour l'air de dilution qui réduit la température des produits de combustion quittant la chambre, celle-ci étant entourée par un intervalle contenant de l'air sous pression s'écoulant à contre-courant du courant desdits produits de combustion, cet intervalle entourant aussi une chambre de prémélange dans laquelle le carburant est mélangé avec l'air de combustion et qui est positionnée en amont de ladite chambre de combustion et en est séparée par un étranglement, caractérisé en ce que ledit air de combustion est prélevé dans ledit intervalle par l'intermédiaire d'une série d'ouvertures formées dans la surface extérieure de la chambre de prémélange et coopérant avec des ouvertures correspondantes d'un tambour pouvant tourner sur ladite surface extérieure de la chambre de prémélange, ledit tambour étant entraîné de manière à modifier le degré d'ouverture desdites ouvertures correspondantes, en fonction de la quantité de carburant utilisée, par un actionneur dont le pignon engrène avec un secteur denté faisant corps avec le tambour, et en ce que la surface dudit étranglement est pourvue d'une série de petits trous alimentés avec du carburant supplémentaire.

2. Système de combustion pour des turbines à gaz selon la revendication 1, caractérisé en ce que ladite chambre de prémélange a une section droite annulaire fusionnant avec ledit étranglement de séparation et comprend dans son espace intérieur annulaire une série radiale de tubes perforés alimentés avec le carburant à mélanger.

3. Système de combustion pour des turbines à gaz selon la revendication 1, caractérisé en ce qu'un brûleur central positionné dans ladite chambre de prémélange et alimenté avec du carburant supplémentaire effectue un injection supplémentaire de carburant dans la zone de combustion en aval dudit étranglement.

4. Système de combustion pour des turbines à gaz selon la revendication 2, caractérisé en ce qu'une série d'aubes est présente en étant réglée préalablement suivant un angle réglable prédéterminé par rapport au courant de mélange air-carburant dans l'espace intérieur annulaire de ladite chambre de prémélange à proximité dudit étranglement.

5. Système de combustion pour des turbines à gaz selon la revendication 1, caractérisé en ce que la partie de la surface de la chambre de combustion qui correspond à la zone de combustion en aval de l'étranglement ne comporte pas d'ouvertures, et, conjointement avec une paroi extérieure pourvue d'un grand nombre de petits trous rapprochés les uns des autres, définit une petite chambre de refroidissement qui communique avec la chambre de combustion par l'intermédiaire de trous collecteurs formés dans l'extrémité de ladite petite chambre qui se trouve plus loin dudit étranglement.

Patentansprüche

1. Verbrennungsanlage für Gasturbinen, mit einer Brennkammer, die mit kleinen, über die gesamte Kammerfläche verteilten Öffnungen für die Kammerkühlluft versehen ist und mit Löchern für die Verdünnungsluft, welche die Temperatur der aus der Kammer ausströmenden Verbrennungsprodukte herabsetzt, wobei die Kammer von einem Zwischenraum umgeben ist, der dem Strom der genannten Verbrennungsprodukte entgegenströmende Druckluft enthält und ebenfalls eine Vormischkammer umgibt, in welcher der Kraftstoff mit der Verbrennungsluft vermischt wird und die in Arbeitsrichtung vor der Brennkammer angeordnet und von dieser durch einen Bereich von verkleinertem Querschnitt getrennt ist,
dadurch **gekennzeichnet**, daß

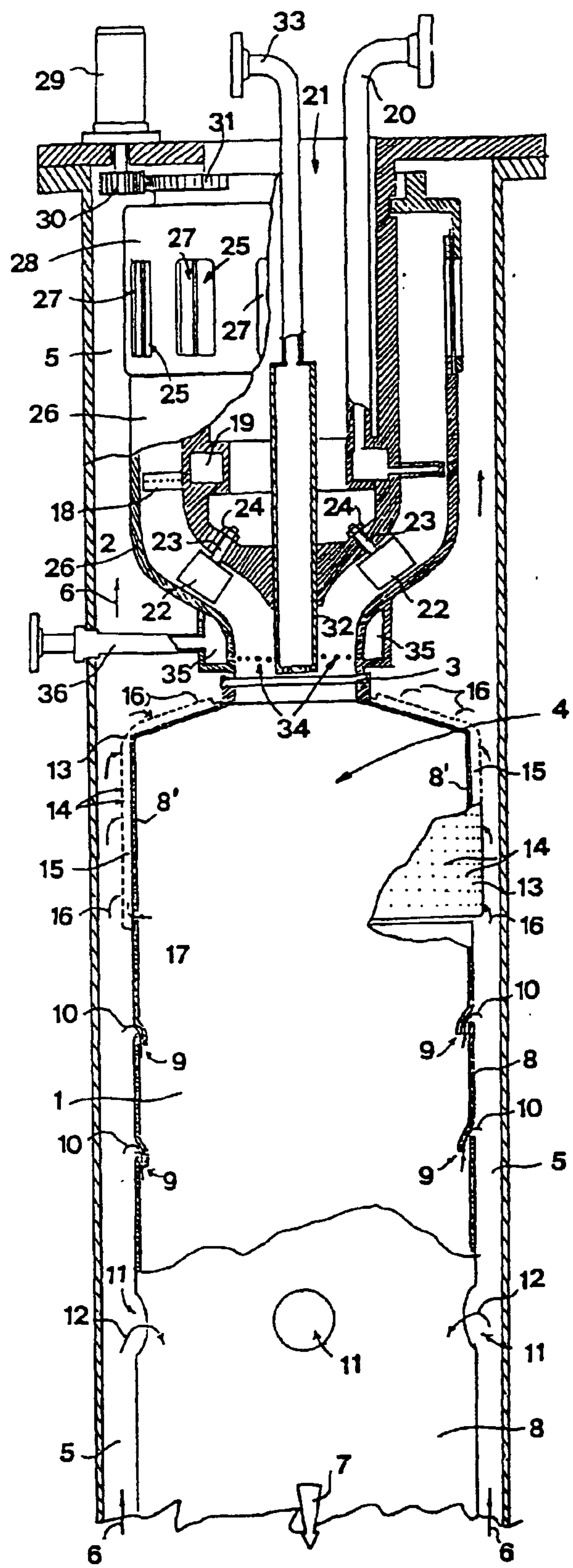
- die Verbrennungsluft aus dem Zwischenraum über eine Reihe von in der Außenfläche der Vormischkammer ausgebildeten und mit entsprechenden Öffnungen in einer auf der Außenfläche der Vormischkammer drehbaren Trommel zusammenwirkenden Öffnungen entnommen wird, wobei die Trommel zur Veränderung des Öffnungsgrades der genannten entsprechenden Öffnungen in Übereinstimmung mit der verbrauchten Kraftstoffmenge durch ein Stellorgan angetrieben wird, dessen Zahnritzel in einen mit der Trommel starr verbundenen Zahnsektor eingreift, und daß
- in der Fläche des Bereichs von verkleinertem Querschnitt eine Reihe kleiner, mit zusätzlichem Kraftstoff versorgter Löcher ausgebildet ist.

2. Verbrennungsanlage für Gasturbinen nach Anspruch 1,
dadurch **gekennzeichnet**, daß
die Vormischkammer eine ringförmige Querschnittsgestalt aufweist, die in den trennenden Bereich von verkleinertem Querschnitt stetig übergeht, und in ihrem ringförmigen Innenraum eine radiale Reihe perforierter Rohre aufweist, denen der zu mischende Kraftstoff zugeleitet wird

3. Verbrennungsanlage für Gasturbinen nach Anspruch 1,
dadurch **gekennzeichnet**, daß
ein in der Vormischkammer angeordneter und mit zusätzlichem Kraftstoff versorgter zentraler Brenner eine weitere Kraftstoffeinspritzung in die in Arbeitsrichtung dem Bereich von verkleinertem Querschnitt nachgeordnete Verbrennungszone durchführt.

4. Verbrennungsanlage für Gasturbinen nach Anspruch 2,
dadurch **gekennzeichnet**, daß
eine Reihe Schaufeln vorgesehen ist, die mit einem vorbestimmten einstellbaren Winkel zum Luft-Kraftstoffgemisch-Strom im ringförmigen Innenraum der Vormischkammer in der Nähe des Bereichs von verkleinertem Querschnitt im voraus eingestellt sind.

5. Verbrennungsanlage für Gasturbinen nach Anspruch 1,
dadurch **gekennzeichnet**, daß
der Abschnitt der Brennkammerfläche, welcher der in Arbeitsrichtung dem Bereich von verkleinertem Querschnitt nachgeordneten Verbrennungszone entspricht, keine Öffnungen aufweist und zusammen mit einer Außenwand, die mit einer großen Anzahl gering beabstandeter kleiner Löcher versehen ist, eine kleine Kühlkammer begrenzt, die mit der Brennkammer über Sammellöcher verbunden ist, die in dem dem Bereich von verkleinertem Querschnitt entgegengesetzten Endabschnitt der genannten kleinen Kammer ausgebildet sind.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